

## CLAIMS

1. An object positioning and attitude estimation system, comprising:
  - a grating assembly associated with a reference location, which generates a fringe interference pattern;
  - a viewer mountable on an object for capturing an image of a fringe pattern generated by the grating assembly; and
  - a processor in communication with the viewer for measuring the generated fringe pattern and, based thereon, determining the orientation of the object relative to the reference location.
2. The system of claim 1, wherein the grating assembly comprises at least two planar gratings in a fixed spatial relationship to each other.
3. The system of claim 2, wherein the grating assembly includes gratings of different properties.
4. The system of claim 1, wherein the grating assembly further comprises a light source.
5. The system of claim 4, wherein the light source is a visible light source.
6. The system of claim 1, wherein the grating assembly relies on ambient light.
7. The system of claim 1 wherein the system includes at least one optical marker to provide a rough estimate of distance and orientation.
8. The system of claim 7 wherein the optical marker defines a border around the pattern generator.
9. The system of claim 7 wherein the system includes one or more corner markers.
10. The system of claim 7 wherein the marker provides reference information for rectification of the fringe pattern data.
11. The system of claim 1, wherein the grating assembly includes portions having different mesh sizes.

12. The system of claim 11, wherein the grating assembly includes a top grating having a smaller mesh size than a bottom grating.
13. The system of claim 11, wherein the grating assembly includes adjacent portions having different mesh sizes.
14. The system of claim 1, wherein the viewer comprises a camera.
15. The system of claim 1, wherein the processor comprises an image processor that determines the orientation of the interference pattern, determines the distance to the pattern emitter, and extracts the phase of the interference pattern.
16. A method of determining position relative to a interference pattern generator, comprising capturing an image of an interference pattern from a known fringe pattern generator with a viewer;
  - determining the phase of the interference pattern with a processor;
  - using the phase information to find the orientation of the viewer relative to the fringe pattern generator;
  - determining the distance to the fringe pattern generator based on the number of fringes in the interference pattern; and
  - determining position relative to the fringe pattern generator.
17. The method of claim 16, wherein the phase of the interference pattern is tracked as the viewer changes in position relative to the fringe pattern generator
18. The method of claim 16, wherein a likelihood estimation algorithm is used by the processor to lift the integer ambiguity.
19. The method of claim 16, including determining the position of a horizon line in the image.
20. The method of claim 18, wherein the location of nadir in the image captured by the viewer is determined.

21. The method of claim 20, wherein the processor determines the angular coordinates on the image plane.

22. The method of claim 21, wherein the equations

$$yc = h \cot(-\alpha_{A1} + \alpha_H) / \cos \beta.$$
$$xc = h \cot(-\alpha_{A2} + \alpha_H) / \sin \beta,$$
$$h = L \sin \beta / (\cot(-\alpha_{B2} + \alpha_H) - \cot(-\alpha_{A2} + \alpha_H)).$$

are solved by the processor and xc, yc, and h are used to correct the orientation of the reference target so that it is viewed in actual dimensions.

23. The method of claim 22, wherein the corrected image is used to determine phase information.

24. The method of claim 22, wherein the equations are used to estimate position data.

25. The method of claim 24, wherein the position data is used to resolve integer ambiguity.

26. Apparatus for determining position, comprising  
a digital processor capable of receiving a digital picture of a fringe pattern from a camera,  
the processor adapted to determine the phase of the fringe pattern based on the digital  
image, determine the distance between the camera and the fringe pattern source based on the  
number of fringes in the pattern, and find the relative position of the camera based on the  
position of the fringe pattern source.

27. A system for determining the position of a vehicle in three dimensions, comprising:  
a known surface including two generally parallel gratings;  
a passive detector for detecting interference fringe patterns created by the known surface;  
and

an image processor which receives the output from the passive detector and uses the output to determine the phase of the interference pattern created by the parallel gratings.

28. A pattern generating navigation aid comprising
  - a grating assembly associated with a reference location, which generates a fringe interference pattern upon illumination, the grating assembly further comprising at least two planar gratings in a fixed spatial relationship to each other; and
  - a source of illumination. A method of determining orientation of an object relative to a reference plane, comprising
    - mounting a grating assembly at a reference location, the grating assembly comprising at least two planar gratings in a fixed spatial relationship to each other;
    - illuminating the grating assembly to generate an interference fringe pattern;
    - imaging the fringe pattern;
    - measuring the phase of the fringe pattern with a detector mounted to the object; and
    - determining the orientation of the object relative to the reference location based on phase measurements.
29. A method of determining location of an object relative to a reference location, comprising
  - identifying a source associated with a reference location, the source generating an interference fringe pattern,
  - extracting geometric information from the source,
  - rectifying an image of the fringe pattern based on the geometric information,
  - determining the location of the object relative to the reference location based on the geometric information and phase measurements.
30. The method of claim 29 wherein the method further comprises estimating an altitude of the object relative to source based on geometric data.
31. The method of claim 29 wherein the method further comprises estimating an angular orientation of the object relative to a plane defined by the source based on geometric data.
32. The method of claim 29 wherein the method further comprises estimating distance based on the geometric data.

33. The method of claim 29 wherein the method further comprises refining a distance measurement based on a measurement of fringe spacing.
34. The method of claim 29 wherein the method further comprises refining an estimate of orientation of the object relative to source based on phase changes in the fringe pattern over time.
35. The method of claim 29 wherein the method further comprises determining location based on a combination of geometric and phase data in which a weighting function is applied to at least one of the geometric or phase measurements over time.